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THE VAPOR PRESSURE OF URANIUM HEXAFLUORIDE*

By R. H. Crist and B. Weinstock

The vapor pressure of uranium hexafluoride, has been determined from 0°C to 85°C in a copper apparatus. The data obtained are given by the two equations

$$\log_{10} P \text{ mm Hg} = - \frac{2623.3}{T} + 10.8407 \text{ (solid, vapor)}$$

$$\log_{10} P \text{ mm Hg} = - \frac{1505.9}{T} + 7.5223 \text{ (liquid, vapor)}$$

and the latent heats are:

$$\Delta H_{\text{sub}} = 12.00 \text{ kg-cal}$$

$$\Delta H_{\text{vap}} = 6.89 \text{ kg-cal}$$

The experimental arrangement is shown in Figure 1. This consists of a reservoir A in a thermostat and a brass sylphon bellows for the measurement of pressure by a null method. The pressure above an atmosphere was read on a multiple mercury manometer using dibutylphthalate as a piston liquid.

At the time the experiments were made, it was thought that only a limited number of metals were safe materials for use with UF_6 accordingly, the vessels and connecting tubes were of copper, the packless valves were brass with a silver gasket ring, the sylphon bellows was brass, and the whole was joined with silver solder or "Phoscopper." To maintain the characteristics of the sylphon, its vertical motion was restricted to about a millimeter by guards on both sides. The inner one served the additional purpose of decreasing the working volume of the system. The lower end of the sylphon was soldered to a copper plate, and the flange at the upper end was held to the top plate of the pressure can by a ring. Butyl rubber served as a gasket. A pointer was attached to the outer sylphon guard, and this was moved by a pin soldered to the sylphon. The pointer and reference were damped by dipping into transformer oil as indicated. The pointer was illuminated and viewed by appropriately located windows.

* This is a reissue of work completed February 9, 1942.

The manometer for reading pressures above an atmosphere was of the multiple type and contained mercury and dibutylphthalate. The latter served as a piston liquid and as a lubricant providing a very satisfactory meniscus. It was not possible to fill the manometer with the two liquids in proper amounts and at the same time keep the dibutylphthalate free from dissolved air. To avoid release of this gas on evacuating the completed unit for use, a permanent head greater than an atmosphere was furnished by having mercury in the limbs standing to appropriate heights. For measurements up to an atmosphere, an ordinary wide tube precision manometer was used. The levels on the multiple manometer were read with a glass plate attached to the sliding arm on the frame of a 3-meter invar scale. All levels were read and the total mercury head was corrected for the difference in the piston liquid levels. All pressure readings were corrected to 0°C.

Two special points in construction might be mentioned. To join copper to thick walled glass capillary, the latter was drawn down and given a burnt in coating of bright platinum. (See Figure 2) This was fitted into a 2-mm wall silver tube, to which was soldered the copper stock. The glass silver joint was made vacuum tight by silver chloride. This was done by heating the unit somewhat above the melting point of silver chloride and holding the tip of a stick of the latter to the joint, when it filled immediately. The union was very strong, but to eliminate any danger of breaking, the whole joint was surrounded with a brass tube which was filled with a glycerin-litharge cement.

The packless "Kerotest" valves used were not vacuum tight. To accomplish this, a gasket ring of thin annealed silver sheet was put in under the stainless steel diaphragm.

All parts of the apparatus containing the UF_6 to be measured were heated to around 100°C, to prevent any condensation of vapor. This included the upper part of the pressure can.

The samples of UF_6 used for the measurements were supplied by Homer Priest and were resublimed over solid KF several times before using. The first portion was put into the apparatus and left standing for several days to condition the inside surfaces which had baked out as well as possible. An appropriate amount was then sublimed into the reservoir for measurement.

The equilibrium was approached, as indicated in Table 1 both by heating and cooling to the desired temperature. Considerable difficulty was experienced in achieving equilibrium for the solid-vapor system at the lower temperatures, in particular at 0°C. Care was taken to maintain the null indicator around the rest point to prevent undue strain on the sylphon and pointer system. For a final setting, the null point was always approached from the same direction.

The data are given in Table 1 and shown on a two scale plot in Figure 3. The first measurements, indicated by the numeral I were made with a sample of UF_6 sublimed a number of times over solid potassium fluoride. On making measurements at higher temperatures and then cooling to -79°C, a noncondensable gas (2 to 6 mm) remained. This noncondensable gas was removed by repeated heating above room temperature,

then cooling to 0°C and pumping. The measurements on the sample from then on are indicated by the numeral II. A second sample of specially purified UF_6 used for the measurements at high temperature is denoted by III. The asterisk indicates that the equilibrium was approached from high temperature side. The measurement marked IV was made at a later date with a third sample of UF_6 and an equimolar amount of solid potassium fluoride present.

For obtaining numbers II and III data, the sample was at equilibrium pressure for 30 to 60 minutes. The 0°C point was measured many times, the most satisfactory data being that obtained with number III sample. The first sample I came to equilibrium very slowly when the approach was from room temperature, and much more rapidly when from below 0°C or on a sample pumped around 0°C or lower.

The temperatures were measured to about 0.05°C , but are reported to the nearest 0.1°C . An error of $\pm 0.1^{\circ}\text{C}$ introduces an error in the pressure of about 3 mm at 60°C and 5 mm at 85°C . The error in reading the manometer was about 2 mm in the higher pressures and less than 0.5 mm at the lower ones.

Comparison of the observed pressures with those calculated from the least square equations shows that the solid-vapor equation reproduces the data to better than 2%. The liquid-vapor equation is good to better than 1%.

Table 1. Vapor Pressure of UF₆

Sample No.	Temp °C	P _{exp} mm Hg	P _{cal} mm Hg	P _{cal} - P _{exp}	
Solid					
$\log P = 10.8407 - \frac{2623.3}{T}$					
III	0	16.9	17.2	+	0.3
I	21.6	88.3	86.9	-	1.4
I	35.5	216.8	218.9	+	2.1
I	40.0	295.4	290.0	-	5.4
I	45.0	397.8	392.6	-	5.2
II		395.8		-	3.2
I	50.0	522.1	526.7	+	4.6
I	55.0	711.1	700.3	-	10.8
II		697.2		+	3.1
II	60.0	910.0	923.3	+	13.3
III	63.1	1072	1091	+	19.0
Liquid					
$\log P = 7.5223 - \frac{1505.9}{T}$					
II	65.0	1169	1170	+	1.0
II	67.9	1273	1277	+	4.0
II	70.1	1360	1363	+	3.0
IV	70.2	1366	1367	+	1.0
III		1370		-	3.0
III*		1376		-	9.0
III	75.2	1582	1580	-	2.0
III*	75.3	1568	1585	+	17.0
III*	80.3	1830	1324	-	6.0
III		1838		-	14.0
III	85.4	2087	2098	+	11.0

Note:

- I is first sample
 II is first sample purified
 III is second sample
 IV is a new sample measured one month later with an equimolar amount of KF present.
 * indicates that the equilibrium was approached from higher temperatures.

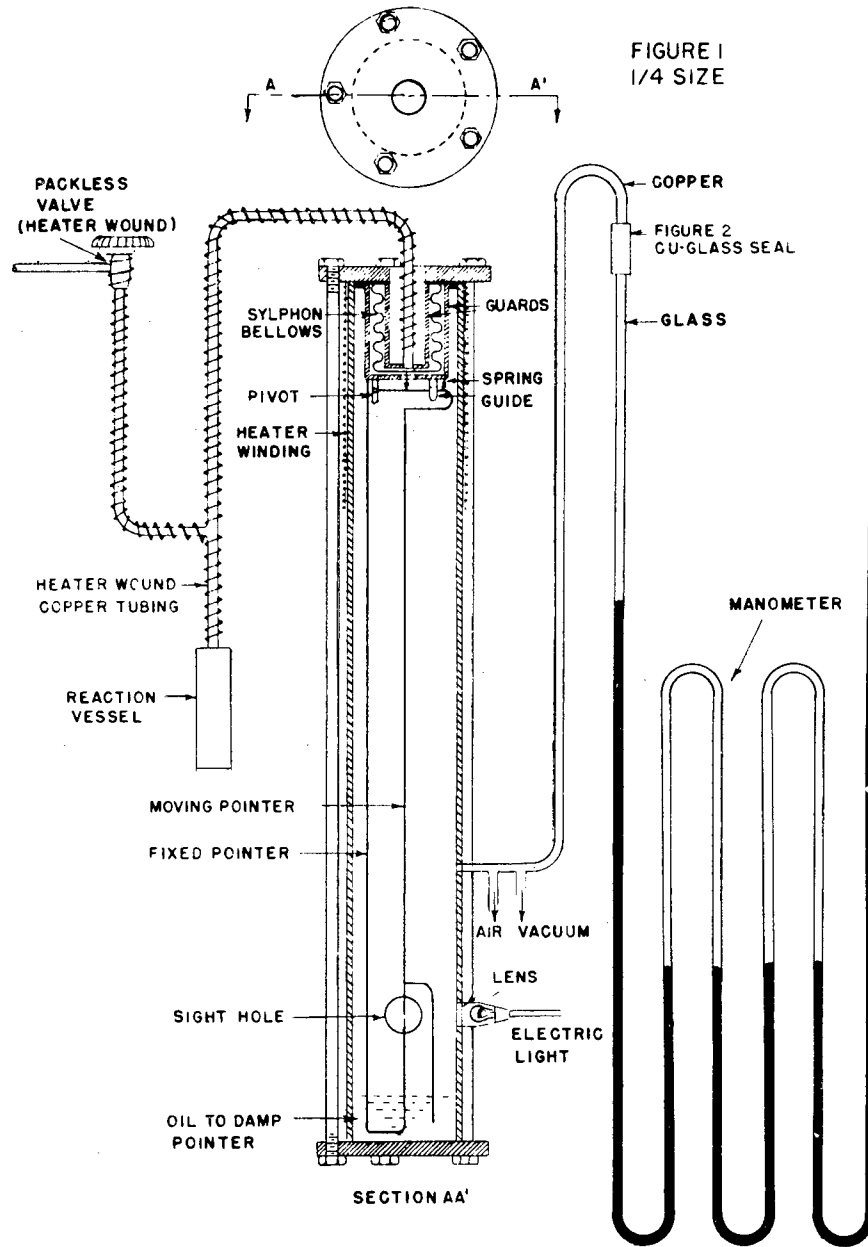
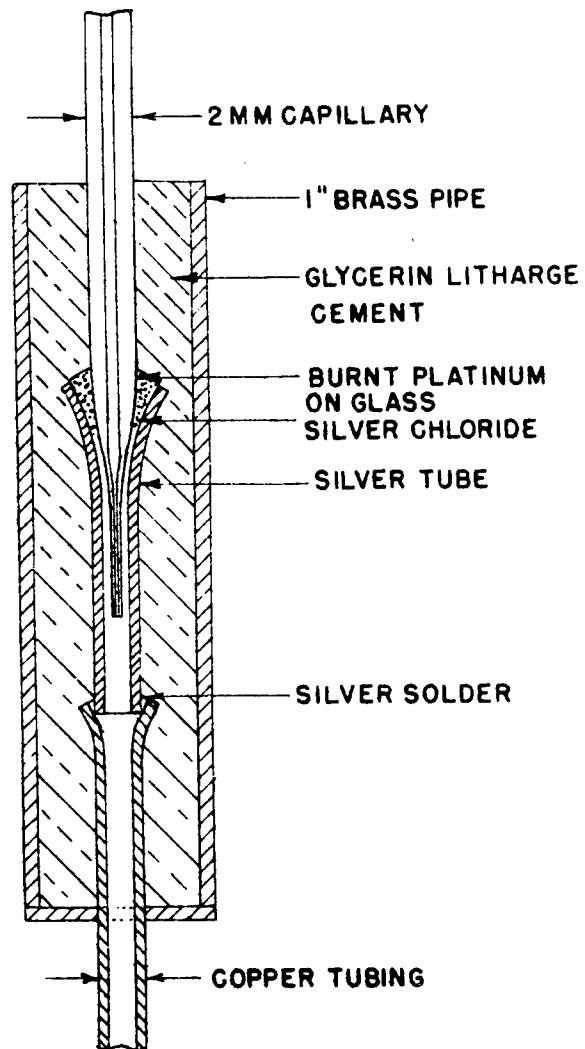
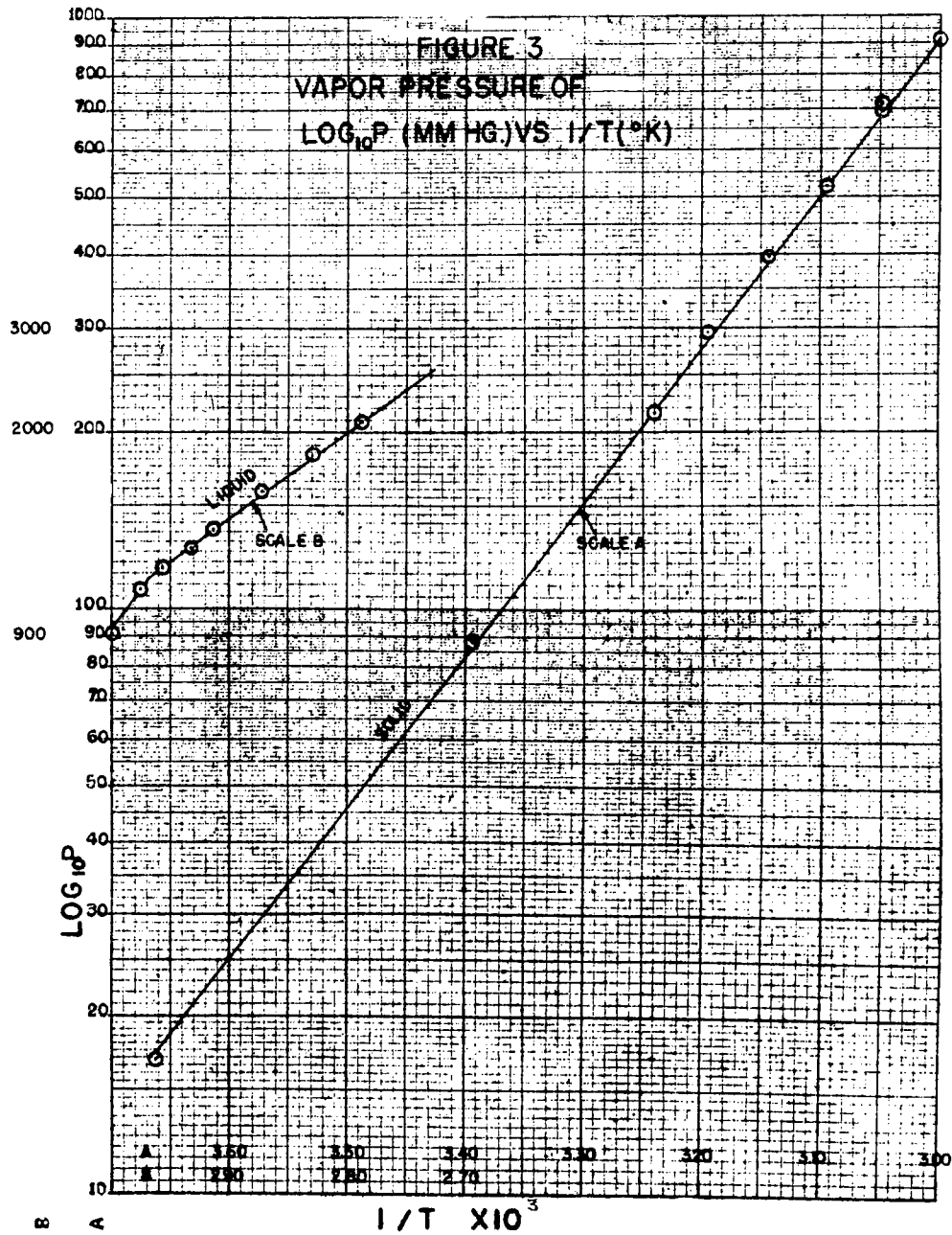


FIGURE 2





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